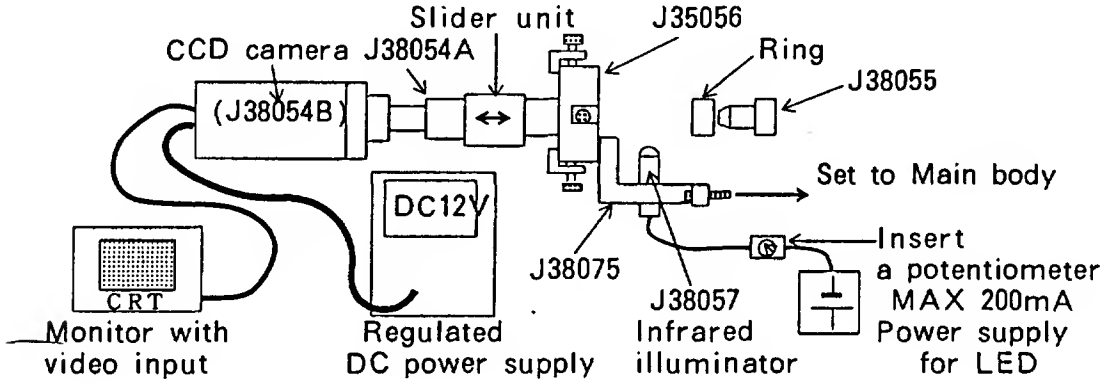
1994.10.12

Nikon
OPHTHALMIC TECHNICAL SERVICE

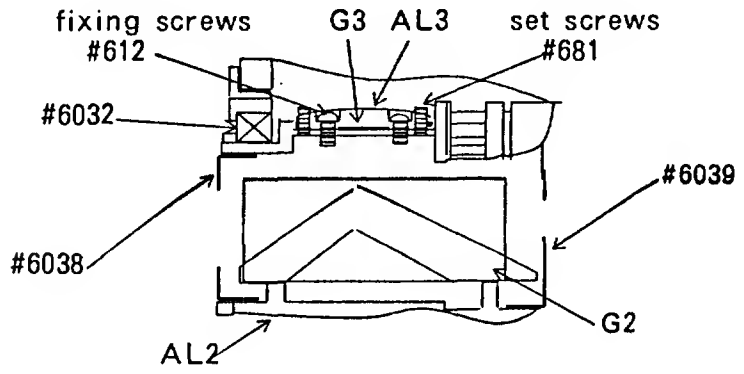
*** NRK-8000 Adjustment Procedures ***

••• Part of Auto Refractometer •••

(1) Adjusting the Image Rotator (IR)
- Remove the Mire ring illuminator(AL10) and K.LED 3(AL12) (if necessary).
- Set the Centering tool(J35056) with Attachment(J38075) on front part of the main body and the Optical adjustment TV tool(J38054) with the CCD camera (J38054B) on the Centering tool(J35056).

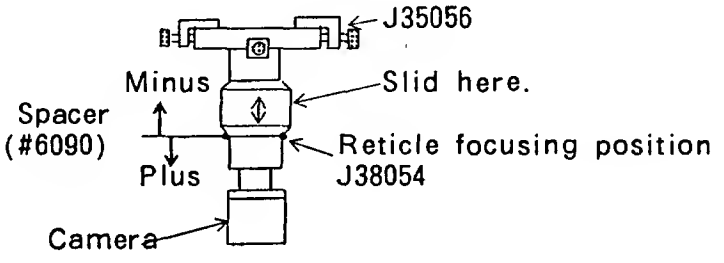


- Tear off the Molt plane(#6024) located beneath the G1 mirror(AL1). Then, set the LED illuminator(J38057) on the Centering tool attachment (J38075). (Remove K.LED 3(AL12) if a parts interference occurs.)
- Turn on the LED illuminator(J38057). Turn off the M.LED(AL5).
- Insert a shielding plate between the CCD camera(#1817) lens on the main body and the AL6 mirror to shield off the external light.
- Focusing : Slide the slider unit of the Optical adjustment TV tool(J38054A) forward and backward to focus on the reticle.
- Alignment : Adjust the knob on the Centering tool(J35056) to align the center of the reticle and the Photo detector.
- Check : Turn the IR (Image Rotator,AL2) from 0 degree to 180 degrees. Make sure that the center of the Photo detector(on #1802) returns to the center of the reticle after the Photo detector image is turned 360 degrees.
- Adjustment : Adjust the fixing screws and set screws to adjust the tilt of of the G3 mirror(AL3) on the IR(AL2).



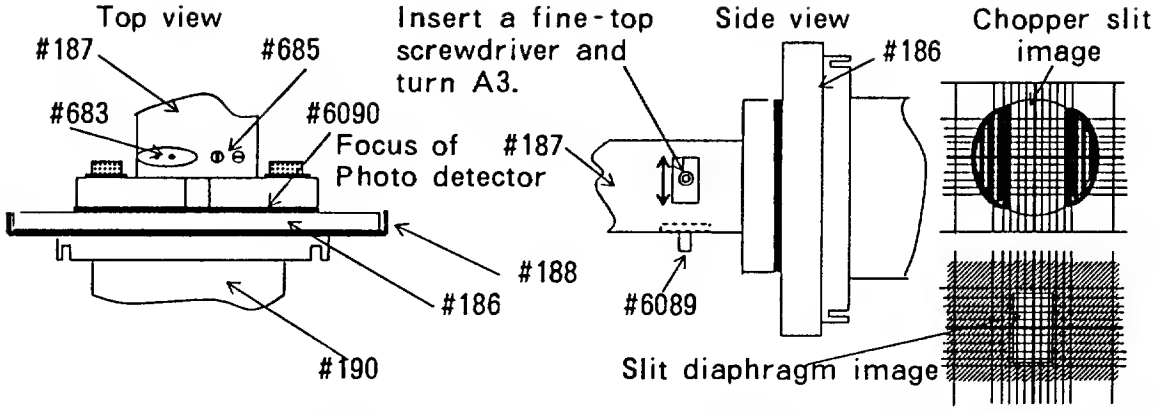
• Check : Turn the IR(AL2) from 90 degrees to 270 degrees.
Make sure that the center of the Photo detector(on #1802) returns to the center of the reticle after the Photo detector image is turned 360 degrees.
Deviation of up to one reticle line width is in tolerance.
• Adjustment : Readjust the tilt of the G3 mirror (AL3) on the IR(AL2) to make same amount of the deviation when the IR(AL2) is rotated from 0 degree to 180 degrees and from 90 degrees to 270 degrees.
If the deviations are too big, replace the IR(AL2).

•• Focusing error of the Photo detector
• If the Photo detector image does not focus on the reticle of the Optical adjustment TV tool(J38054A) at the reticle focusing point with TV camera. Adjust the spacer(#6090) thickness on the Photo detector box mount plate (#186) to focus the Photo detector on the reticle.



• Move the slide unit forward and backward to find the position where the Photo detector image focuses on the reticle.
• The focusing position of the Photo detector image is on the centering tool (J35056) side against the reticle focusing position.
——→ Make the spacer thinner.
• The focusing position of the Photo detector image is on the camera side against the reticle focusing position.
——→ Make the spacer thicker.

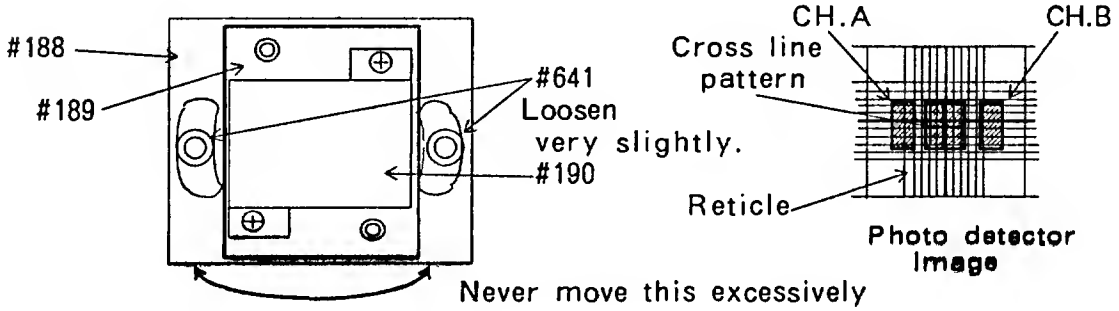
(2) Adjusting the Chopper slit and the Slit aperture inclination
• Attach the Supplement lens with a ring(J38055) at the end of the Optical adjustment TV tool(J38054A).
• Turn off the LED illuminator(J38057). Turn on the M.LED(AL5).
——→ The Chopper slit(#6057) image will be visible.
• Chopper slit inclination : Turn the IR(AL2) until the Chopper slit(#6057) image is in parallel with the vertical lines of the reticle.
(Does not rotate the IR after alignment.)
• Remove the Supplement lens ring(J38055) at the end of the Optical adjustment TV tool(J38054A) and attach only the the Supplement lens(J38055) again.
• Turn off the M.LED(AL5).Turn on the LED illuminator(J38057).
——→ The Slit aperture(A3) image will be visible.
• Check : Make sure that the Slit aperture(A3) image is in parallel with the vertical lines of the reticle.
Make sure also that the Slit aperture(A3) image is in focus.
• Adjustment : Turn the Slit aperture(A3) until the the Slit aperture image is in parallel with the vertical lines of the reticle.
Loosen two screws(#683) then turn the Slit aperture(A3) through the tool hole.



If the Slit aperture(A3) image is found out of focus, loosen two #685 set screws and, using the #6089 pin, move the Slit aperture(A3) back and forth so that the image focus on the reticle.

(3) Adjusting the Photo detector inclination

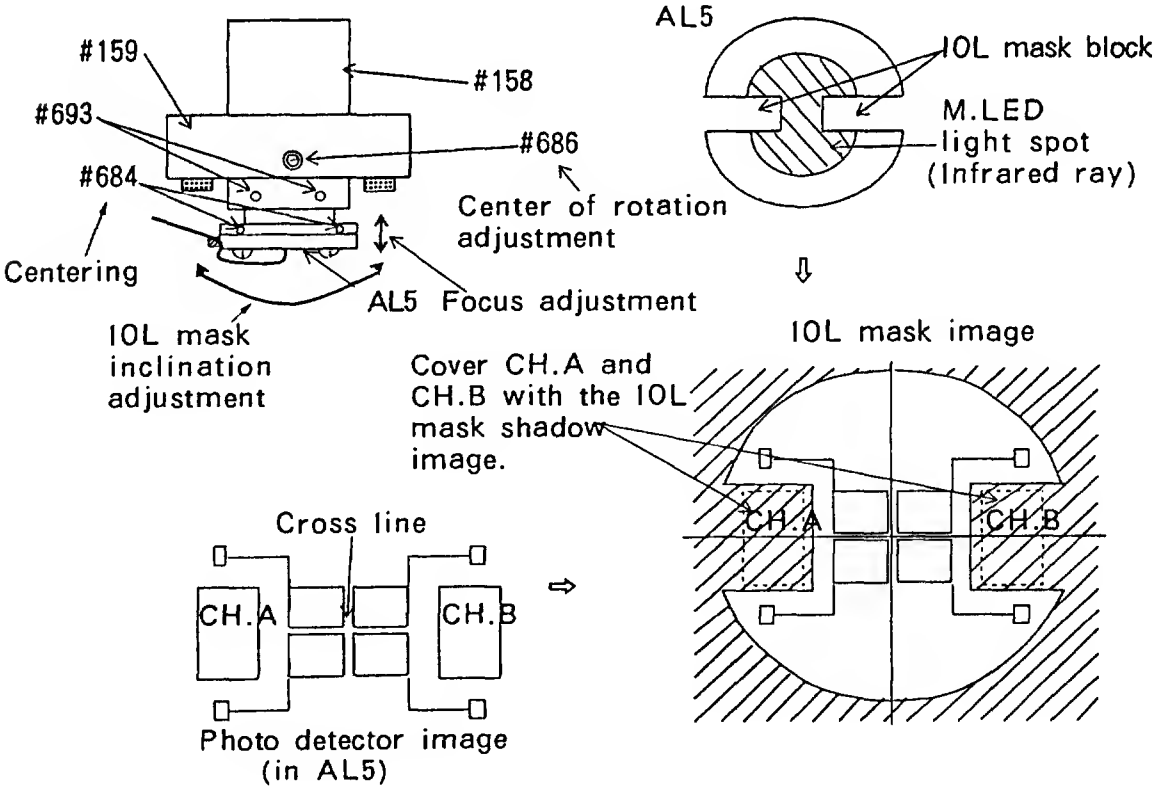
- Attach the Supplement lens with a ring(J38055) at the end of the Optical adjustment TV tool(J38054A).
- Turn off the LED illuminator(J38057). Turn on the M.LED(AL5).
  ⟶ The Chopper slit(#6057) image will be visible.
- Chopper slit inclination : Turn the IR(AL2) until the chopper slit image is in parallel with the vertical lines of the reticle.
  (Does not rotate the IR after alignment.)
- Remove the Supplement lens with a ring(J38055) at the end of the Optical adjustment TV tool(J38054A).
- Turn off the M.LED(AL5).Turn on the LED illuminator(J38057).
  ⟶ The Photo detector image will be visible.
- Check : Make sure that the cross line pattern of the Photo detector (on #1802) is in parallel with the cross lines of the reticle.
- Adjustment : Slightly loosen the two #641 allen bolts and turn the Photo detector board mount plate(#189) so that the cross line pattern of the Photo detector(on #1802) is in parallel with the cross lines of the reticle.



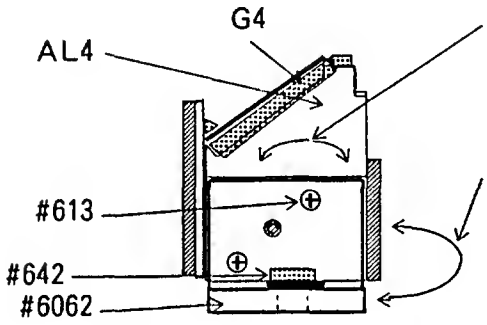
(4) Adjusting the M.LED position and the G4 mirror

- Turn off the M.LED(AL5).Turn on the LED illuminator(J38057).
  ⟶ The Photo detector(on #1802) image will be visible.
- Photo detector position : Adjust the knob on the Centering tool(J35056) to match the center of the reticle and the cross line of Photo detector(on #1802).

- Photo detector inclination : Turn the IR(AL2) to make in parallel the cross line of Photo detector(on #1802) image and reticle.
  This time, the CH.A and CH.B in the Photo detector(on #1802) image are positioned right beside and in parallel with the horizontal lines of the reticle.
  (Does not rotate the IR after alignment.)
- Turn off the LED illuminator(J38057). Turn on the M.LED(AL5).
- M.LED light spot focusing : Loosen the two #693 set screws and slide the M.LED(AL5) up and down to focus the outline of the IOL mask(in AL5).
  Check : Make sure that the M.LED(AL5) light spot is centered at the IOL mask (in AL5). If a deviation is found, adjust the M.LED(AL5) light spot position by the four #684 set screws.
- M.LED inclination adjustment : While performing focus adjustment, rotate the M.LED(AL5) to be in parallel with the horizontal lines of the reticle and IOL mask block.
- Turn off the M.LED(AL5).Turn on the LED illuminator(J38057).
- Check : Make sure that the CH.A and CH.B of Photo detector(on #1802) is covered with the IOL mask shadow image.
- Check : Rotate the IR(AL2) from 0 degree to 90 degrees.
  Make sure that the IOL mask image is rotated by 180 degrees and the center of image returns to the center of the reticle.
- Adjustment : Slide the Light source tube(#158) horizontally by the four #686 set screws to adjust the position of the M.LED(AL5).



- Fine adjustment : Carry out fine adjustment by moving the G4 mirror(AL4) position.



Vertical direction :
Loosen only one of two #613 screws and swing the G4 mirror assemble(AL4) vertically.

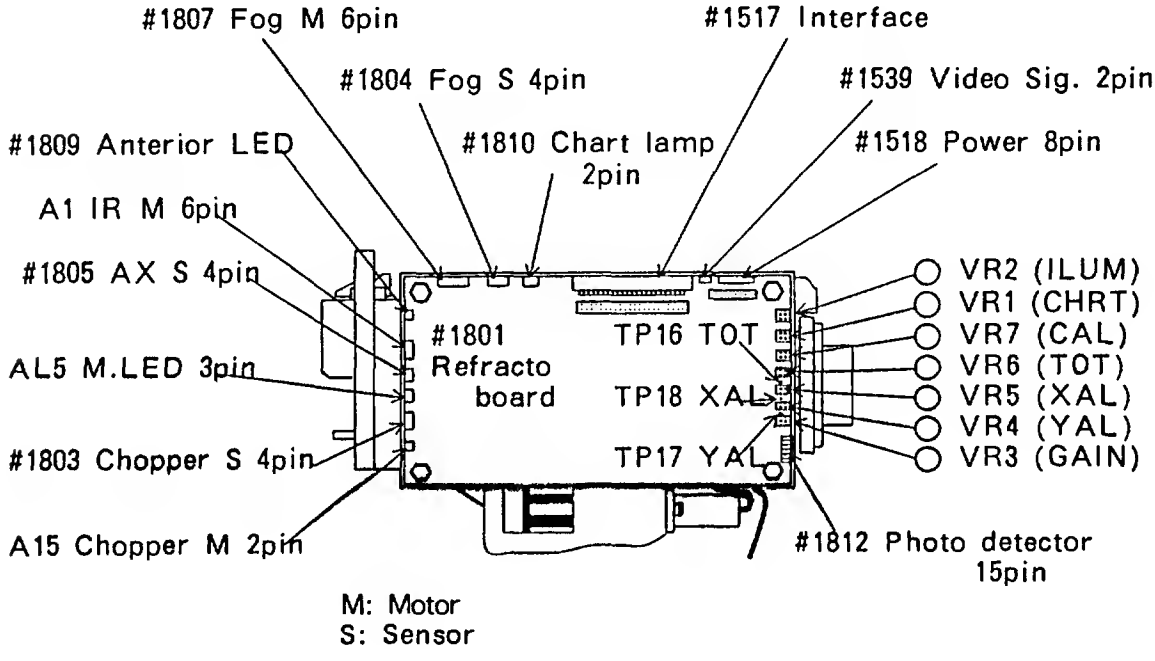
Horizontal direction :
Loosen only one of two #642 screws and swing the G4 mirror assemble(AL4) with the block mount(#6062) horizontally.

- Remove the LED illuminator(J38057) from the Centering tool attachment (J38075).
Glue the malt plane(#6024) to cover the hole of beneath the G1 mirror(AL1) with Priobond(Konishi bond G17).

(5) TEST 01 Adjusting A/D converter
- Remove the Optical adjustment TV tool(J38054A) with CCD camera(J38054B) from the Centering tool(J35056).
- Enter the Refracto test program mode. Select TEST-0D.
- Check : R ⟶ 126~135 (for a reference voltage of 0.25V).
0 ⟶ 000 (0.00V)
- Adjustment : Adjust the potentiometer on the Refracto board(#1801).

T	⟶ R	±10	VR6 (TOT)
X	⟶ R	±10	VR5 (XAL)
Y	⟶ R	±10	VR4 (YAL)
A&B	⟶	150~200	(CHA-FIL,CHB-FIL) VR7 (CAL)

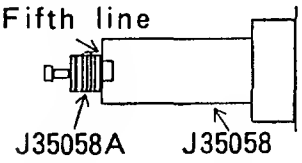
- Potentiometer and connector positions (on the Refracto board)



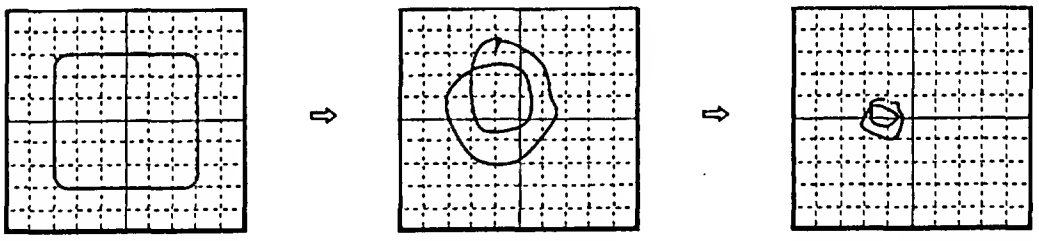
M: Motor
S: Sensor

(6) TEST 01 IR rotation check and model eye alignment (use an Oscilloscope)

- Mount the Model eye attaching tool(J35058) on the Centering tool(J35056).
- Connect the Probes for the Oscilloscope on the Refracto board(#1801).
  CH 1 (X) ⟶ TP18 (XAL)
  CH 2 (Y) ⟶ TP17 (YAL)
- Set the Oscilloscope : SEC/DIV ⟶ X - Y mode
  VOLTS/DIV ⟶ CH 1 0.2 or 0.1V (1:1)
  CH 2 0.2 or 0.1V (1:1)
  INPUT COUPLING ⟶ CH 1 DC
  CH 2 DC
  Ground ⟶ DG
- Select TEST 01. Press the 「MLED OFF」 key to turn the "MLED ON".
- Oscilloscope zero adjustment : Pull the Model eye out from the Model eye attaching tool(J35058).
  Use the POSITION knob to align the light spot with the center of the screen.
- Model eye focusing position : Attach the Model eye on the model eye adapter (J35058A) and insert them into the Model eye attaching tool(J35058).
  Align the fifth line of the Model eye adapter (J35058A) with the edge of the the Model eye attaching tool(J35058) and fix the adapter.
  This position is the model eye's reference focusing position.



- Model eye alignment : Press the 「IRM STOP」 key to turn the "IRM ROT".
  Adjust the knob on the Centering tool(J35056) to make the rotation of the light spot on the screen as small as possible.



Find the square movement the rotating light spot.

Keep a circular movement and make smaller.

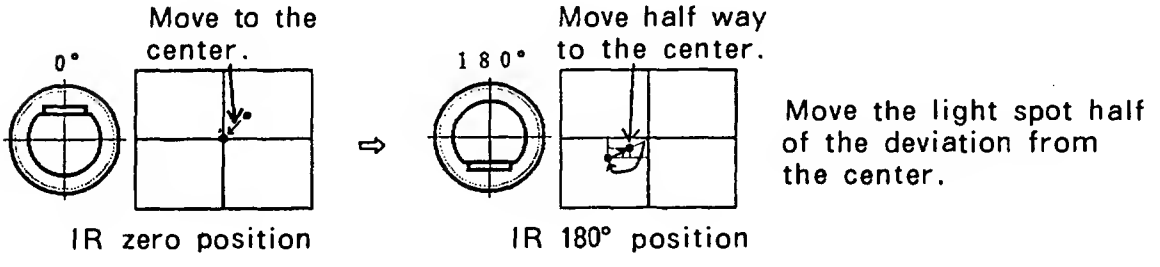
Make the light spot movement as small as possible.

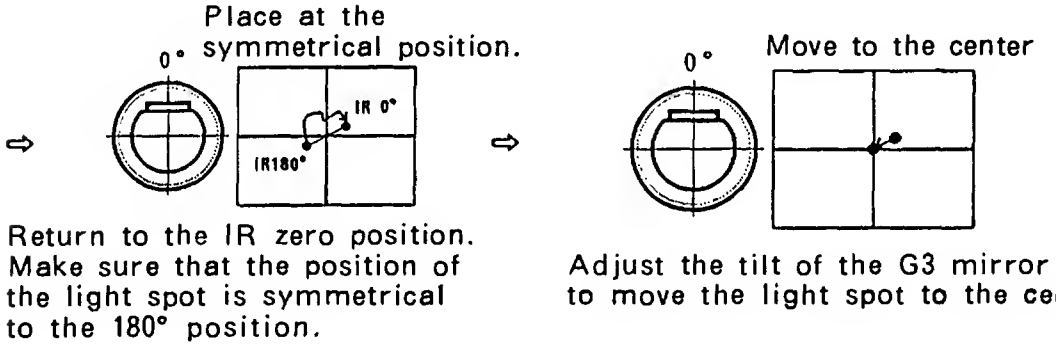
- Check : Make sure that the smallest circular movement of the light spot comes inside four cells(2x2).
  If the movement of the light spot rotation is too large, readjust the tilt of the G3 mirror(AL3) of IR(AL2) according to the IR fine adjustment procedure while observing the movement of the light spot on the Oscilloscope screen.

•• Fine adjustment of IR

- Press the 「IRM ROT」 key to turn the "IRM STOP" and stop the rotation of the IR(AL2).
- Disconnect the IR motor(A1) connector from the J5 connector on the Refracto board(#1801).
- IR zero position adjustment : Turn the IR(AL2) by hand until the G3 mirror (AL3) comes on top.
- Adjustment of the light spot on the Oscilloscope screen :
  Adjust the POSITION knob to align the light spot with the center of the screen.
- IR 180 degree position : Turn the IR(AL2) 180 degrees by hand.
  The G3 mirror(AL3) will be positioned to bottom.

- Light spot positioning : Read the position of the light spot on the Oscilloscope screen with the IR(AL2) position set to 180 degrees.
  Then, adjust the POSITION knob so that the light spot is positioned half of the reading deviation from the center of screen.
- Checking the symmetric position of the light spot :
  Return the IR(AL2) to the zero position.
  Make sure that the position of the light spot is symmetric to the IR 180 degree position. If not, adjust the POSITION knob to move the light spot so that its position is symmetric to the IR 180 degree position.
- Light spot center positioning : Adjust the fixing screws and set screws to adjust the tilt of the G3 mirror(AL3) on the IR(AL2) so that the light spot is moved to the center of the screen.

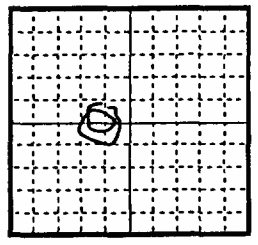

Move to the center.
0°
Move half way to the center.
180°
Move the light spot half of the deviation from the center.
IR zero position
IR 180° position


Place at the symmetrical position.
0°
IR 0°
IR180°
Return to the IR zero position. Make sure that the position of the light spot is symmetrical to the 180° position.
0°
Move to the center
Adjust the tilt of the G3 mirror to move the light spot to the center.

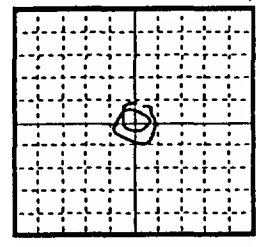
- Check : Make sure that all screws are tightened evenly when the adjustment of the fixing screws and set screws is completed.
  Rotate the IR continuously by the TEST 01 mode to make sure that the minimum circle of the light spot movement comes inside four cells(2x2) on the Oscilloscope screen.

(7) Adjusting the position of the Photo detector
- Connect the IR motor(A1) connector into the connector J5 on the Refracto board(#1801).
- Select TEST 01. Press the [MLED OFF] key to turn the "MLED ON".
- Oscilloscope zero adjustment: Pull the model eye out from the Model eye attaching tool(J35058).
  Use the POSITION knob to align the light spot with the center of the screen.
- Model eye focusing position : Attach the Model eye on the Model eye adapter (J35058A) and insert them into the Model eye attaching tool(J35058).
  Align the fifth line of the Model eye adapter (J35058A) with the edge of the the Model eye attaching tool(J35058) and fix the adapter.

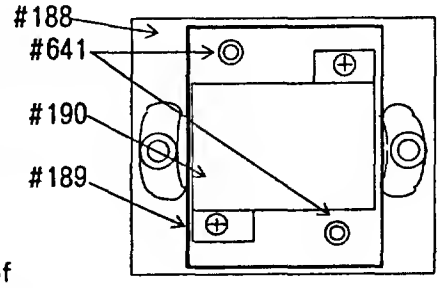
- Model eye alignment : Press the [IRM STOP] key to turn the "IRM ROT". Adjust the knob on the Centering tool(J35056) to make the rotation of the light spot on the screen as small as possible.
- Check : Make sure that the center of rotation of the light spot is on the center of the screen.



Make the movement of the light spot as small as possible.



Move the center of rotation to the center of the screen.

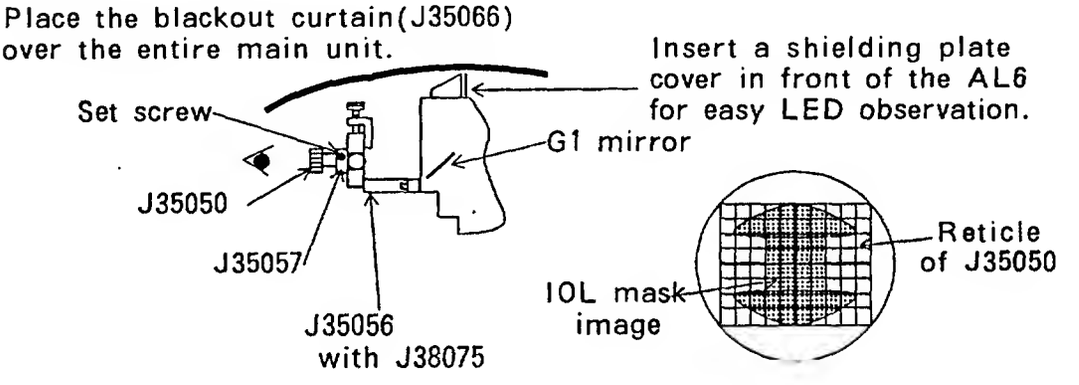


- Adjustment: Slightly loosen the two #641 allen bolts.
  Tap on edge of the Photo detector mount plate(#189) so that the Photo detector board(#1802) position steps and the light spot moves toward the center of the screen.
  Use caution because the light spot will scale out of the screen if Photo detector board(#1802) movement is too large.
  Make sure that the Photo detector board(#1802) does not incline.

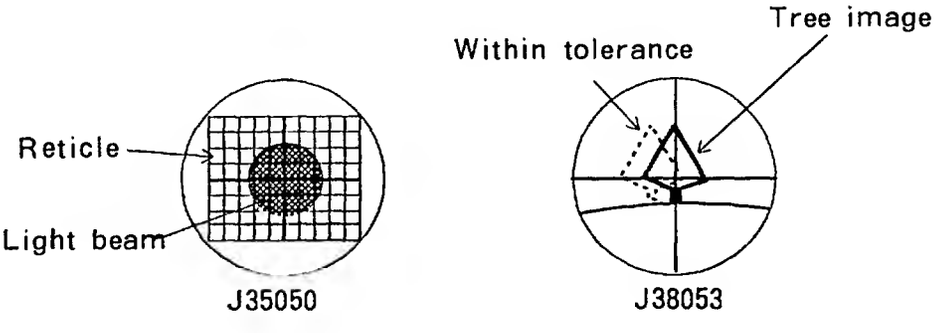
(8) TEST 0E Checking the IR optical adjustment
- Select TEST 0E.
- Model eye focusing position : Attach the Model eye on the Model eye adapter (J35058A) and insert them into the Model eye attaching tool(J35058).
  Align the fifth line of the Model eye adapter (J35058A) with the edge of the the Model eye attaching tool(J35058) and fix the adapter.
- Model eye alignment : Adjust the knob on the Centering tool(J35056) to set "XAL" and "YAL" to "000".
  Make sure that "TOT" is not set to "000".
- Adjust the "TOT" value to "094" using the VR3 on the Refracto board(#1801) (Because there is no the Mire ring illuminator(AL10).)
- "[X][Y]" measurement : Press the Measurement button(#1528).
  The IR(AL2) will rotate and measured values appear.
- Check : Make sure that the measured values of "[X][Y]" are "35" or less.
- Adjustment : If a measured value of "[X][Y]" is bigger than "35", perform steps (6) and (7) to readjust the IR(AL2) and Photo detector(on #1802) positions.
- After adjustment : Shield the circumference of the G3 mirror(AL3) mount and IR(AL2) with black KE45.
  (After black KE45 dries out, re-execute TEST 0E for confirmation).

(9) Adjusting the Fixation chart

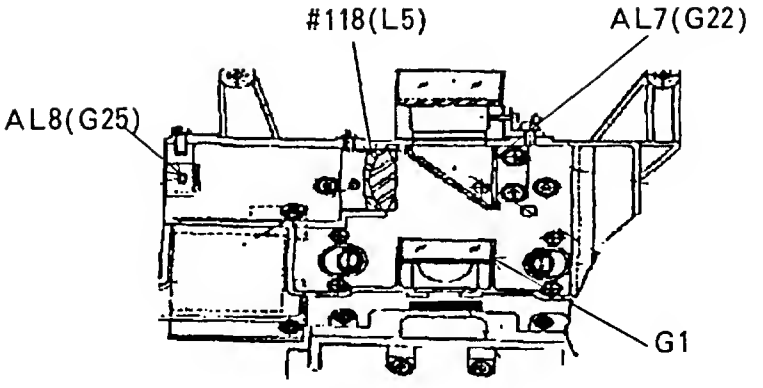
- Remove the Model eye attaching tool(35058) from the Centering tool(J35056).
- Mount the Eyepiece retaining ring(J35057) on the Centering tool(J35056). Insert the Eyepiece with reticle(J35050) into the Eyepiece retaining ring (J35057).
- Disconnect the Fixation chart lamp(#1810) connector from the J8 connector on the Refracto board(#1801).
- Select TEST 04. Press the 『MLED OFF』 key to turn the "MLED ON" and to turn on the M.LED(AL5).
- M.LED focusing adjustment : Place the Blackout curtain(J35066) over the main unit.
  Observe through the Eyepiece with reticle (J35050) under the blackout curtain(J35066), slide the Eyepiece with reticle(J35050) back and forth to focus the Mask image on the M.LED (AL5) with the reticle.
  Then, tighten the set screw on the Eyepiece retaining ring(J35057).


Place the blackout curtain(J35066) over the entire main unit.
Insert a shielding plate cover in front of the AL6 for easy LED observation.
Set screw
G1 mirror
J35050
J35057
J35056 with J38075
Reticle of J35050
IOL mask image

- Eyepiece positioning : Adjust the knob on the Centering tool(J35056) to move the mask image on the M.LED(AL5) to the center of the Reticle.
- Press the 『MLED ON』 key to turn the "MLED OFF" and to turn off the M.LED(AL5).
- Connect the Fixation chart lamp(#1810) connector into the J8 connector on the Refracto board(#1801).

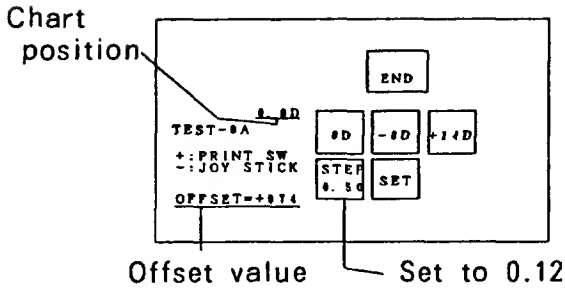


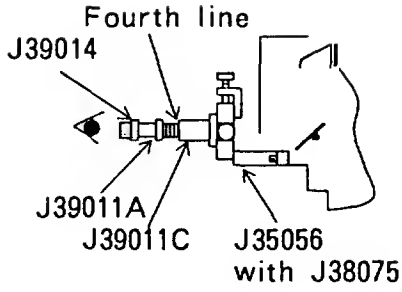
- Select TEST 0A.
- **Light beam position adjustment : Move the light beam to the center of the reticle.**
  Vertical direction ——→ Move the G25 mirror(AL8) parallelly.
  Horizontal direction —→ Move the G22 mirror(AL7) parallelly.
- Remove the Eyepiece with reticle(J35050) and replace the Centering telescope (J38053).
- Slide the inner tube of the Centering telescope(J38053) back and forth to focusing to the Tree image on the reticle.



- Tree image chart position adjustment : Move the Tree image chart(AL9) to the center of the reticle.
  Vertical direction ——→ Swing the G25 mirror(AL8) horizontally.
  Horizontal direction —→ Swing the G22 mirror(AL7) vertically.
- Tolerance : Light beam position adjustment
  ——→ On the center of the Eyepiece(J35050) reticle.
  Tree image chart position adjustment
  ——→ The Tree image must be touch to the center of the Centering telescope(J38053) reticle.
  Adjust the light beam and Tree image chart positions alternately until both comes inside their tolerance.
- Adjust the VR1 on the Refracto board(#1801) to set the intensity of the chart illuminator(#1810) to its maximum.
- Inclination of the Tree image chart :
  Remove the Eyepiece with reticle(J35050) or Centering telescope(J38053). Then, observe the Tree image chart with a naked eye to ensure that the image stands upright.
- Tree image chart Inclination adjustment :
  Turn the Fixation chart(AL9) to adjust the inclination of the Tree image chart.

(10) TEST 0A Fixation chart focus adjustment
- Select TEST 0A.
- Remove the Eyepiece retaining ring(J35057) from the Centering tool(J35056).
- Mount the Inspecting telescope holder C(J39011C) on the Centering tool (J35056). Insert the Inspecting telescope(J39014) into the Inspecting telescope holder A(J39011A).
  And insert them(J39014 & J39011A) into the Inspecting telescope holder C (J39011C).
- 0.00Dpt. position adjustment : Press the 「STEP 0.50」 key twice to turn the "STEP 0.12".
  Move the Tree image chart to the best focus position using the [PRINT] key(on #1503) and Measurement button(#1528).
  This position is indicated as the "OFFSET" value. Store this "OFFSET" value in EEPROM.
- Store to EEPROM : Set the DIP switch No. 5 to the ON position to enable storing. Press the 「SET」 key, and the "OFFSET" value will be stored into the EEPROM with two beeps.
- After store to EEPROM : Be sure to return the DIP switch No. 5 to the OFF position to the EEPROM store protection.





- +10.00Dpt. position : Mount the -10.00Dpt. Inspecting lens(J39015) on the tip of the Inspecting telescope holder A(J39011A). Insert the Inspecting telescope(J39014) and the Inspecting telescope holder A(J39011A) with Inspecting lens(J39015) into the Inspecting telescope holder C (J39011C) and fix them at the fourth line.

  Check : Press the 「STEP 0.50」 key twice to turn the "STEP 0.12". Move the Tree image chart(AL9) to the best focus position using the [PRINT] key(on #1503) and Measurement button(#1528). Read this chart position and make sure that the read value is within the tolerance.

  Tolerance : +9.625Dpt. ~ +10.375Dpt.
- -10.00Dpt. position : Mount the +10.00Dpt. Inspecting lens(J39016) on the tip of the Inspecting telescope holder A(J39011A). Insert the Inspecting telescope(J39014) and the Inspecting telescope holder A(J39011A) with Inspecting lens(J39015) into the Inspecting telescope holder C (J39011C) and fix them at the fourth line.

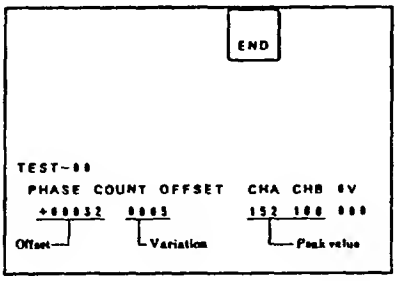
  Check : Press the 「STEP 0.50」 key twice to turn the "STEP 0.12". Move the Tree image chart(AL9) to the best focus position using the [PRINT] key(on #1503) and Measurement button(#1528). Read this chart position and make sure that the read value is within the tolerance.

  Tolerance : −9.625Dpt. ~ −10.375Dpt.
- Adjustment : When shifting the range of +10.00Dpt. to -10.00Dpt..
  ——→ Slide the Fixation relay lens(L5) horizontally.
  When changing the range of +10.00Dpt. to -10.00Dpt..
  ——→ Move the entire part of the Fixation chart box back and forth.
- Readjustment : After adjusting the fixation chart position by moving the Fixation relay lens(L5) and the Fixation chart box, repeat steps (9) and (10) for readjustment.

(11) TEST 03 TOT adjustment (VR3)
- Mount the Mire ring illuminator(AL10) and K.LED 3(AL12).
- Set the Model eye attaching tool(J35058) on the Centering tool(J35056).
- Select TEST 03.
- Model eye focusing position : Attach the Model eye for M.LED power check (0.00Dpt.,J39029) on the Model eye adapter (J35058A) and insert them into the Model eye attaching tool(J35058).
  Align the fifth line of the Model eye adapter (J35058A) with the edge of the Model eye attaching tool(J35058) and fix the adapter.
- Model eye alignment : Adjust the knob on the Centering tool(J35056) to set "XAL" and "YAL" to "000".
  At this time, make sure that the "TOT" value is close to "085".
- Adjustment : Adjust the "TOT" value to "085" using the VR3 on the Refracto board (#1801).

(12) TEST 06 Checking the phase count offset for CH.A and CH.B

- Select TEST 06.
- Check : The value of "PHASE COUNT OFFSET" must be within "-200" to "+200" and its variation must be "0010" or less.



(13) Adjusting the CCD camera position

- Select TEST 03.
- Model eye focusing position : Attach the Model eye on the Model eye adapter (J35058A) and insert them into the Model eye attaching tool(J35058).
  Align the fifth line of the Model eye adapter (J35058A) with one edge of the Model eye attaching tool(J35058) and fix the adapter.
- Model eye alignment : Adjust the knob on the Centering tool(J35056) to set "XAL" and "YAL" to "000".
  At this time, make sure that the "TOT" value is close to "085".
- CCD camera position adjustment
  M.LED light spot focusing : Slide the CCD camera(#1817) with the mount back and forth to make a smallest size of light spot image on the TV monitor(#1522) of the M.LED(AL5).
  M.LED light spot position : While keeping the size of the M.LED light spot at minimum, adjust the position of the CCD camera(#1817) mount to center the light spot image of the M.LED(AL5) on the TV monitor (#1522).
- CCD camera tilt : Adjust the knob on the Centering tool(J35056) to move the model eye vertically.
  Make sure that the light spot image of the M.LED(AL5) on the TV monitor(#1522) moves vertically.
  Adjustment : Rotate the CCD camera(#1817) body itself on the mount by loosing three or four #612 screws.
- Alignment mark position : Press the 「U」 「D」 「L」 and 「R」 keys to move the Alignment mark on the TV monitor(#1522) until the light spot image of the M.LED(AL5) falls at the center of the Alignment mark.
  Store this position to EEPROM.
- Store to EEPROM : Set the DIP switch No. 5 to the ON position to enable storing. Press the 「SET」 key, and the the Alignment mark position will be stored into the EEPROM with two beeps.
- **After store to EEPROM : Be sure to return the DIP switch No. 5 to the OFF** position to the EEPROM store protection.

(14) TEST 0C Making of the model eye count table

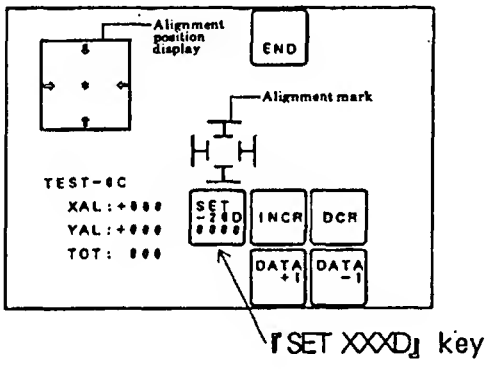
- Select TEST 0C. Press the [PRINT] key(on #1503) to print out the current count table data.
- +22.00Dpt. Model eye count check : Attach the +22.00Dpt. model eye (J38052A) on the Model eye adapter(J35058A) and insert them into the Model eye attaching tool(J35058).
  Align the fifth line of the Model eye adapter(J35058A) with the edge of the Model eye attaching tool(J35058) and fix the adapter.

  Model eye alignment : Adjust the knob on the Centering tool (J35056) to set "XAL" and "YAL" to "000".
  At this time, make sure that the "TOT" value is close to "085".

  Measuring the count : Press the Measurement button(#1528) to start counting.

  Check : Make sure that the measured count value shown in the "SET -26D" key is within the range of "3850" to "3950".

  Adjustment in case of out of the range of "3850" to "3950 :
  Move the Slit diaphragm(A3) position back and forth to be measured count falls within the range of "3850" to "3950".
- Press the 「END」 key to exit the TEST 0C temporarily.
- Select TEST 0C again.



- Manual input of -26.00Dpt. to -20.00Dpt. Model eye count value :
  The Count values displayed in the "SET XXXD"" key fields

Model eye power	Model eye count values (Dummy count values)
-26.00 Dpt. ⟶	0 0 0 0
-24.00 Dpt. ⟶	0 0 5 0
-22.00 Dpt. ⟶	0 0 7 0
-20.00 Dpt. ⟶	0 1 0 0

  Input the dummy count values using the 「DATA +1」 and 「DATA -1」 keys.

  Store to EEPROM : Set the DIP switch No. 5 to the ON position to enable storing. Press the 「SET XXXD」 key, and the Count value will be stored into the EEPROM with two beeps.
  Store the model eye count into the EEPROM for each model eye power.
- Selecting the Model eye power:
  「INCR」 key ⟶ Changes the power in the plus direction in 2.00Dpt. step increment in "SET XXXD" key.
  「DCR」 key ⟶ Changes the power in the minus direction in 2.00Dpt. step increment in "SET XXXD" key.

- Input of -18.00Dpt. to +22.00Dpt. Model eye count :

  Model eye attaching ⟶ Mount the -18.00Dpt. Model eye(in J39033) on the Model eye adapter(J35058A) and insert them into the Model eye attaching tool (J35058).
  Press the 「INCR」 key to select "SET -18D".

  Model eye focusing ⟶ Slide the Model eye adapter(J35058A) back and forth in the Model eye attaching tool (J35058) and to make the smallest size of the light spot image of the M.LED(AL5) on the TV monitor(#1522).
  Or, align the fifth line of the Model eye adapter(J35058A) with the edge of the Model eye attaching tool(J35058).
  Then, fix the adapter.

  Model eye alignment ⟶ Adjust the knob on the Centering tool (J35056) to set "XAL" and "YAL" to "000". (where the "TOT" value is close to "085")

  Measurement ⟶ Press the Measurement button(#1528), and the IR (AL2) will rotate and automatic measurement start. The measured value is displayed in the "SET -18D" key field. Measure the model eye count several times and determine the average value using the 「DATA+1」 and 「DATA-1」 keys.

  Store to EEPROM ⟶ Set the DIP switch No. 5 to the ON position to enable storing. Press the 「SET -18D」 key, and the Count value will be stored into the EEPROM with two beeps.

  Changing the Model eye power ⟶ Press the 「INCR」 key to select "SET -16D". Remove the -18.00Dpt. Model eye, mount the -16.00Dpt. Model eye (in J39033)on the Model eye adapter (J35058A) and insert them into the Model eye attaching tool(J35058).

  ••• Repeat the above steps to measure the model eye count for Model eye powers of -18.00Dpt. to +22.00Dpt. in 2.00Dpt. increment and to store the measured count values in the EEPROM.

- Manual input of +24.00Dpt. to +26.00Dpt. Model eye count :
  Count values displayed in the "SET XXXD"" key fields

Model eye power	Model eye count values (Dummy count values)
+24.00 Dpt. ⟶	4 0 9 4
+26.00 Dpt. ⟶	4 0 9 6

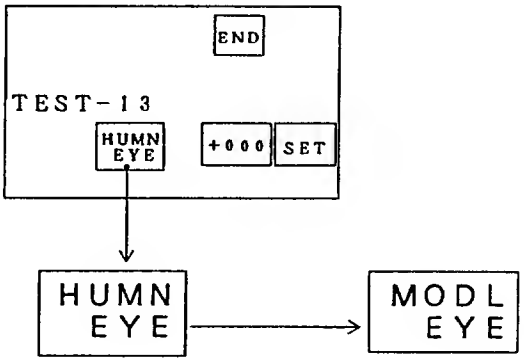
  Input the dummy count values of model eye using the 「DATA +1」 and 「DATA -1」 keys.

  Store to EEPROM : Set the DIP switch No. 5 to the ON position to enable storing. Press the 「SET XXXD」 key, and the Count value will be stored into the EEPROM with two beeps.
  Store the model eye count into the EEPROM for each model eye power.

- After store to EEPROM : Be sure to return the DIP switch No. 5 to the OFF position to the EEPROM store protection.
- Printing the new Count table data :
  Press the [PRINT] key, and the Counts table data that have been stored in the EEPROM will be printed out.
  Compare these values with the old values printed in advance.

(15) Model eye measurement

- Select TEST 13.
- Press the 「HUMN EYE」 key to enter the "MODEL EYE".



- Press the 「END」 key to exit from the TEST 13 mode. Press the 「EXIT」 key on the Refracto test program select menu screen, and "M" will appear in the "R/L" field and enter the tool model eye measurement mode.
- Check Model eye measuring accuracy :

Model eye attaching ⟶ Mount the Model eye on the Model eye adapter(J35058A) and insert them into the Model eye attaching tool(J35058).

Model eye focusing ⟶ Slide the Model eye adapter(J35058A) back and forth in the Model eye attaching tool (J35058) to make the smallest size of the light spot image of the M.LED(AL5) on the TV monitor(#1522).
Or, align the fifth line of the Model eye adapter(J35058A) with the edge of the Model eye attaching tool(J35058).
Then, fix the adapter.

Model eye alignment ⟶ Adjust the knob on the Centering tool (J35056) for align the M.LED light spot image on center of the Alignment mark on the TV monitor(#1522).

- Measurement : Make measurements on the Model eyes from -16.00Dpt. to +22.00Dpt. in 2.00Dpt. step.
  Press the Measurement button(#1528), measure more than five times for each Model eye.
- Check : Make sure that the measured data fall within the tolerance.
- If measured value is out of tolerance :

When the measured data of the SPH power is within the tolerance.
⟶ Adjust the count value of the model eye whose SPH power does not fall within the tolerance using the 「DATA+1」 and 「DATA-1」 keys in the TEST 0C.
Restore the new count value in the EEPROM.

When the measured data of the CYL power does not fall within the tolerance.
⟶ Check and readjust the optical system again.

• Tolerance :

Model eye power	Difference between SPH measured data and model eye power	CYL measured data
-16.00Dpt.	within ±0.25Dpt.	within ±0.75Dpt.
-14.00Dpt. -12.00Dpt. -10.00Dpt.	within ±0.25Dpt.	within ±0.50Dpt.
- 8.00Dpt. - 6.00Dpt. - 4.0Dpt.	within ±0.25Dpt.	within ±0.25Dpt.
- 2.00Dpt. 0.00Dpt. + 2.00Dpt.	within ±0.125Dpt.	0.00Dpt.
+ 4.00Dpt. + 6.00Dpt. + 8.00Dpt.	within ±0.25Dpt.	within ±0.25Dpt.
+10.00Dpt. +12.00Dpt. +14.00Dpt.	within ±0.25Dpt.	within ±0.50Dpt.
+16.00Dpt. +18.00Dpt.	within ±0.25Dpt.	within ±0.75Dpt.
+20.00Dpt. +22.00Dpt.	within ±0.25Dpt.	within ±0.75Dpt.

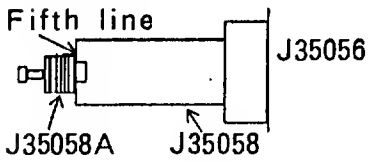
(16) TEST 11 Adjusting the Cylindrical axis

- Enter the normal measurement mode.Set the "+C" or "-C" display to make same sign displayed on the Cyl. model eye(J38056).
- Remove the Centering tool(J35056) with Attachment(J38075) from the main body
- Select TEST 11.
- Mount and set the Cyl. model eye(J38056) on the Forehead rest bar(#A11).
- Slide the main body to adjust the Model eye's focus and alignment.
- Measurement : Press the Measurement button(#1528), Measure the cylindrical axis and displays it in the "AXIS =" field.
  Make several measurements and take their average data as the cylindrical axis.
- Check : The average cylindrical axis must be within ±3 degrees of the displayed axis on the Cyl. model eye(J38056).
- Adjustment : Press the 「INCR」 or 「DCR」 key to make the Cylindrical axis data indicated in the "AXIS =" field equal to the displayed axis on the Cyl. model eye(J38056).
  The "OFFSET" value changes as you press the 「INCR」 or 「DCR」 key.
- Store to EEPROM : Set the DIP switch No. 5 to the ON position to enable storing. Press the 「SET」 key, and the "OFFSET" value will be stored into the EEPROM with two beeps.
- After store to EEPROM : Be sure to return the DIP switch No. 5 to the OFF position to the EEPROM store protection.

••• Part of Auto Keratometer •••

(17) Setting the Model eye position

- Set the Centering tool(J35056) with attachment(J38075) on front part of the main body.
- Mount the Model eye attaching tool(J35058) on the Centering tool(J35056).
- Connect the Probes for the Oscilloscope on the Refracto board(#1801).
  CH 1 (X) ——————→ TP18 (XAL)
  CH 2 (Y) ——————→ TP17 (YAL)
- Set the Oscilloscope : SEC/DIV ——————→ X-Y mode
  VOLTS/DIV ——————→ CH 1 0.2 or 0.1V (1:1)
  CH 2 0.2 or 0.1V (1:1)
  INPUT COUPLING ——→ CH 1 DC
  CH 2 DC
  Ground ——————→ DG
- Select TEST 01 of the Refracto test program mode.
- Press the 『MLED OFF』 key to turn the "MLED ON".
- Oscilloscope zero adjustment : Pull the Model eye adapter(J35058A) out from the Model eye attaching tool(J35058). Use the POSITION knob to align the light spot with the center of the screen.
- Model eye focusing position : Attach the Model eye on the Model eye adapter (J35058A) and insert them into the Model eye attaching tool(J35058). Align the fifth line of the Model eye adapter (J35058A) with the edge of the the Model eye attaching tool(J35058).

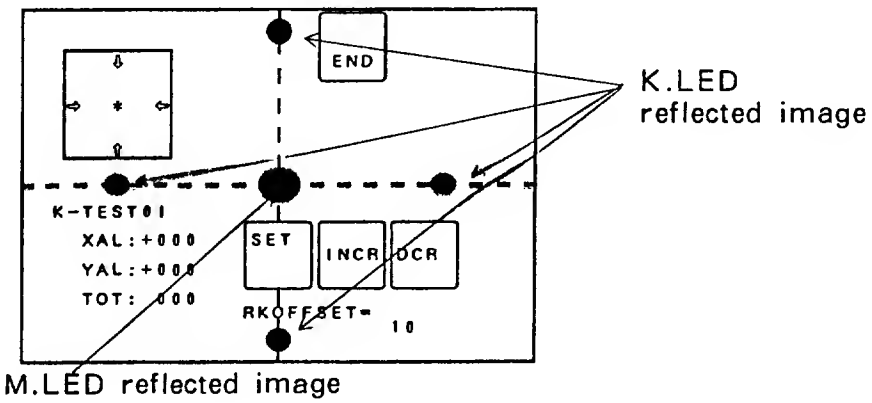


- Model eye alignmment : Press the 『IRM STOP』 key to turn the "IRM ROT".Adjust the knob on the Centering tool(J35056) to make the rotation of the light spot on the screen as small as possible.

(18) TEST K1 Adjusting the K.LED focusing position

- Press the 『KTST』 key in the Refracto test program select menu screen to the Kerato test program mode.
- Select TEST K1.
- Press the measurement button(#1528) to enter the Kerato mode.

The enlarged K.LED image reflected from the Model eye surface appears on the screen.



- Focus adjustment : Slide the CCD camera(#1817) with the mount back and forth to focus the four K.LED(AL11 & AL12) reflected images.
  Find the position where the K.LED(AL11 & AL12) reflected image makes to the most round image.

- K.LED reflected image position adjustment :
  If the four K.LED(AL11 & AL12) reflected images look aslant as a whole
  ——→ Rotate the CCD camera(#1817) on the mount until the four K.LED (AL11 & AL12) reflected images overlap the broken cross line on the screen.
  If one of the K.LED(AL11 & AL12) reflected images is dislocated
  ——→ Adjust the K.LED(AL11 & AL12) assembly position on the main unit.

(19) TEST K1 Adjusting the M.LED focusing position
- Select TEST K1.
- Press the Measurement button(#1528) to enter the Refracto mode.
  The normal size reflected image from the model eye surface appears on the screen.
- Focus adjustment : Move the G17 objective lens in the Ref/Kerato conversion lens case(#169) in and out to find the focusing position of light spot of the M.LED(AL5).
  Find the position where the light spot of the M.LED(AL5) appears smallest and round.
  Fix the lens at this position.

  Focus check : Move the Model eye adapter(J35058A) to find the smallest and round light spot of the M.LED(AL5).
  Make sure the gocus point is located on the fifth line of the Model eye attaching tool(J35058).

  Readjustment : The line is located between the first and the fourth line
  ——→ More move the G17 in the OUT direction.
  The line is located on the sixth or larger line
  ——→ More move the G17 in the IN direction.
  The line is located on the fifth
  ——→ End of the G17 adjustment.

(20) TEST K1 Adjusting the Ref/Kerato conversion position
- Select TEST K1.
- conversion position check : Press the measurement button(#1528) several times to convert between the Refracto and Kerato mode.

  Refracto mode (normal magnification screen)
  ——→ The light spot of the M.LED must be positioned at the center of the broken cross line on the monitor screen.

  Kerato mode (high magnification screen)
  ——→ The four K.LED reflected images must overlap the broken cross line on the monitor screen.
- Adjustment :

  Horizontal direction ——→ Slide the Ref/Kerato conversion lens case (#169) along the shafy of the Ref-Kerato motor(#1807).

  Vertical direction ——→ Rotate the Ref/Kerato conversion lens case (#169) around the shaft of the Ref-Kerato motor(#1807).

  Whenever the Ref/Kerato conversion lens case(#169) position is adjusted, press the [END] key to exit the TEST K1 mode and initialize the Ref/Kerato conversion lens case(#169) position by selecting TEST K1 again.
- Fine adjustment : Adjust the AL6 mirror at the front of the CCD camera (#1807) lens.

  Horizontal direction ——→ Swing the AL6 mirror in the horizontal direction.

  Vertical direction ——→ Tilt the AL6 mirror in the up and down direction.

- Alignment mark position adjustment :
  Adjust the position of the Alignment mark after adjusting the Ref/Kerato conversion position.
  Select TEST 03 of the Refracto test program mode.
  Press the 「U」 「D」 「L」 and 「R」 keys to move the alignment mark until the light spot of the M.LED is on the center of the alignment mark.
  Stored this position in EEPROM.
- Store to EEPROM : Set the DIP switch No. 5 to the ON position to enable storing. Press the 「SET」 key, and the Alignment mark position will be stored into the EEPROM with two beeps.
- After store to EEPROM : Be sure to return the DIP switch No. 5 to the OFF position for the EEPROM store protection.

(21) TEST K1 Adjusting the Ref/Kerato conversion sensor position
- Select TEST K1.
- Connect the Oscilloscope probe : CH1 ⟶ TP8 (RKREF) on the Kerato board(#1821)
- Set the Oscilloscope : SEC/DIV ⟶ 1 ms
  VOLTS/DIV ⟶ CH1 2.0V (1:1)
  INPUT COUPLIN ⟶ CH1 DC
  Ground ⟶ DG DG
- Press the Measurement button(#1528) to enter the Kerato mode. (High magnification screen)
- Check : Press the 「DCR」 key to set the "RKOFFSET" value to "1".
  Press the 「INCR」 key to change the value of "RKOFFSET" to "2","3", and "4" and go on.

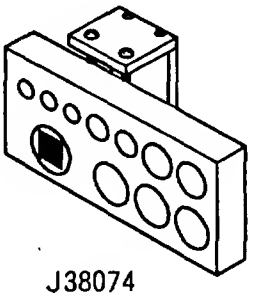
RKOFFSET = 1 ⟶ Low (0V,ground)
⇩⇧
RKOFFSET = 2 ⟶ High (Around 5V) Low
⇩⇧
RKOFFSET = 3 ⟶ High Low
⇩⇧
RKOFFSET = 4 ⟶ High

Find the "RKOFFSET" value which the Oscilloscope display switches from Low (0V, ground) to High (approx. +5V).
At this point, press the 「DCR」 and 「INCR」 keys alternately to verify that the display always switches from Low to High and High to Low for certain.
- Adjustment : Move the Ref/Kerato sensor(#1804) back and forth so that the Oscilloscope display switches from Low to High and High to Low for certian.
  Make sure the Ref/Kerato conversion sensor plate(#172) does not touch to the Ref/Kerato sensor(#1804).
- Recheck of after adjustment : Press the 「END」 key to exit the TEST K1 mode temporarily. Select TEST K1 again.
  Check to determine whether the light spot of the M.LED(AL5) is positioned at the center of the broken cross line on the screen in the Refracto mode.
  Also check whether the Ref/Kerato conversion sensor plate(#172) gets in contact with the Ref/Kerato sensor(#1804).
- Adjustment : In case of the M.LED(AL5) is offset verticaly from the center of the broken cross line on the monitor screen.
  Press the 「DCR」 or 「INCR」 key to center the light spot of the M.LED(AL5) with the broken **cross line on the monitor screen.**
  As the "RKOFFSET" value changes when you press the 「DCR」 or 「INCR」 key, store this "RKOFFSET" value to EEPROM.

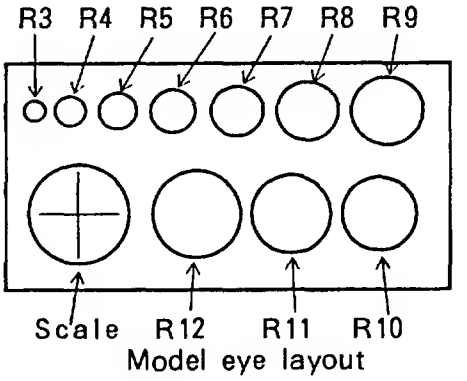
- Store to EEPROM : Set the DIP switch No. 5 to the ON position to enable storing. Press the "SET" key, and the "RKOFFSET" value will be stored into the EEPROM with two beeps.
- After store to EEPROM : Be sure to return the DIP switch No. 5 to the OFF position for the EEPROM store protection.

(22) TEST K2 Checking the K.LED light spot position data

- Mount the Measuring head front cover(A13). Connect the Anterior illuminator (#1809) LED cable into the J9 connector on the Refracto board(#1801).
- Turn the VR2(ILUM) on the Refracto board(#1801) counterclockwise to set the intensity of Anterior illuminator(#1809) to a minimum.
- Set the Model eye for Auto Keratometer(J38074) on the Forehead rest bar(A11)
- Select TEST K2.
- Model eye selection : Move and align the main unit with the R11 model eye.

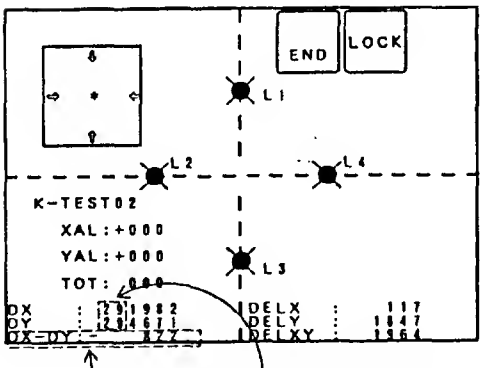


J38074



Model eye layout

- Alignment : Move the main unit vertically and horizontally to overlap the four surrounding K.LED light spots and the broken cross line. Move the main unit back and forth to bring the four K.LED light spots into focus(Find the smallest size of light spots.)
- Positional data display : Press the Measure button(#1528) once. In several seconds, the screen will be frozen and the K.LED light spot positional data will be displayed.
- Check : The higher-order two digits of the "DY" and "DX" values must be same. The "DX-DY" value must be "10000" or less.
- Adjustment : Adjust the fixing position of the K.LED 1 to K.LED 4 assembly.

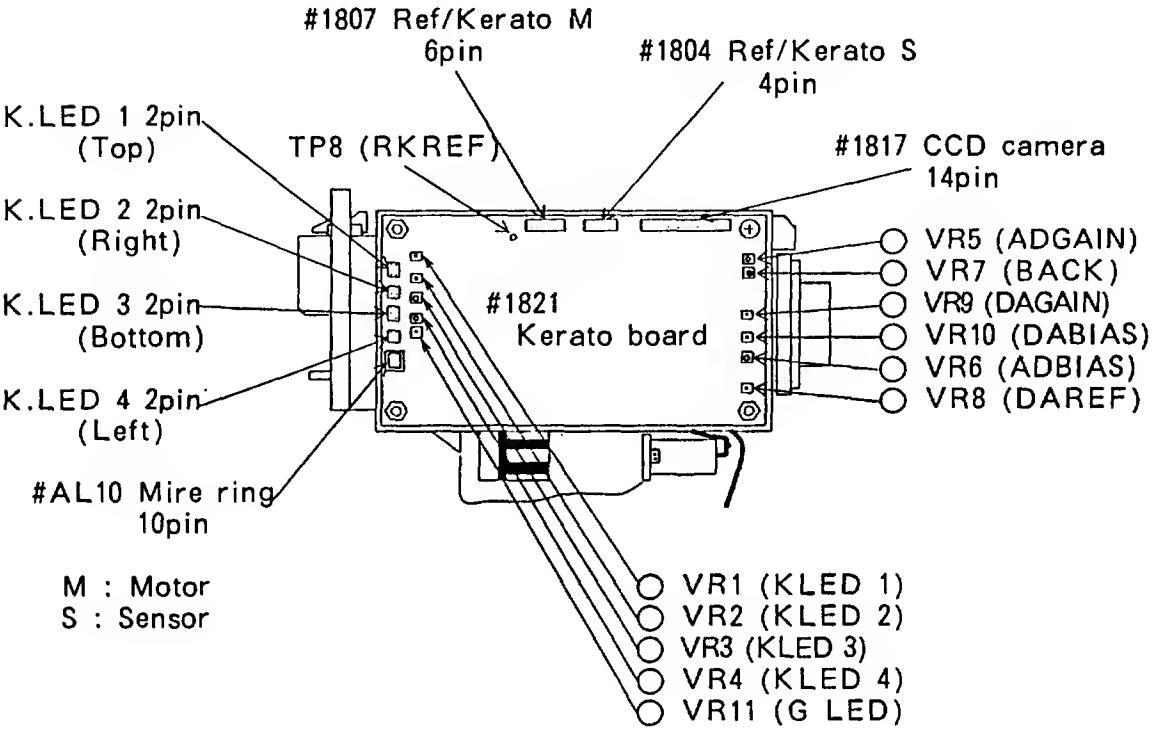


Higher-order two digits

Under 10000

(23) TEST K3 Adjusting the intensity of the K.LED

- Adjusting the intensity of the green LED on the Mire ring illuminator(AL10):
  Turn the VR11(G LED) on the Kerato board(#1821) clockwise to set the intensity to maximum.
- Preliminarily adjusting the K.LED intensity :
  Turn the VR1 to VR4 on the Kerato board(#1821) counterclockwise to set the intensity to a minimum.
  VR1 ——→ for K.LED 1
  VR2 ——→ for K.LED 2
  VR3 ——→ for K.LED 3
  VR4 ——→ for K.LED 4



- Set the Model eye for Auto Keratometer(J38074) on the Forehead rest bar(A11)
- Select TEST K1.
- Model eye selection : Press the Measurement button(#1528) to enter the Kerato mode.
  Move and align the main unit with the R11 model eye.
- Alignment : Move the main unit vertically and horizontally so that the four surrounding K.LED light spots overlap the broken cross line.
  Move the main unit back and forth to bring the four K.LED light spots into focus(Find the round light spots position.)
  At this point, fix the main unit with the clamp(#6392 & #310).
  While taking care not to move the main unit, press the [END] key to exit the TEST K1 mode.
- Select TEST K3. The "MAX" and "MIN" measured values will be displayed.
- Adjustment : Turn the VR5(ADGAIN) and VR6(ADBIAS) on the Kerato board(#1821) counterclockwise to set the "MAX" and "MIN" values to "00".
  "MIN"——→ Adjust the VR5 to "1•".
  "MAX"——→ Adjust the VR6 to "FF".
  "MIN"——→ The displayed value becomes larger than "1•".
  "MIN"——→ Adjust the VR5 to "1•" or minimum.
  "MAX""MIN" ——→ Adjust the "MIN" value to either "1•" or "2•" while keeping the value of "MAX" at "FF" using the VR6.

• K.LED intensity balance check : The "MAX" value of "K1" to "K4" must be"FF" and the "MIN" value must be either "1•" or "2•".

Balance adjustment : If the value of one of "K1" to "K4" is too small.

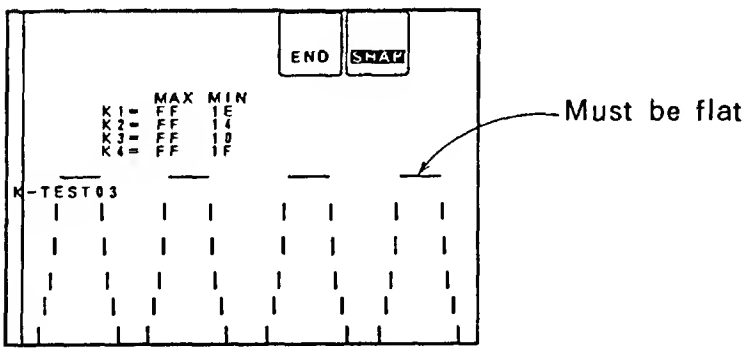
⟶ Increase the intensity of the K.LED with low intensity one.

Adjust one of the VR1 to VR4 on the Kerato board(#1821) with low intensity one.

If the value of one of "K1" to "K4" is too large.

⟶ Increase the intensity of the three K.LED with low intensities.

Adjust three of the VR1 to VR4 on the Kerato board(#1821) with low intensity ones.



• Intensity graph check : Press the 「SHAP」 key.

The intensity graph will be displayed.

Make sure that the waveforms of the four plots are of the same shape, size, and interval.

The tops of each waveform must be flat.

• If the waveform of a plot is found poor :

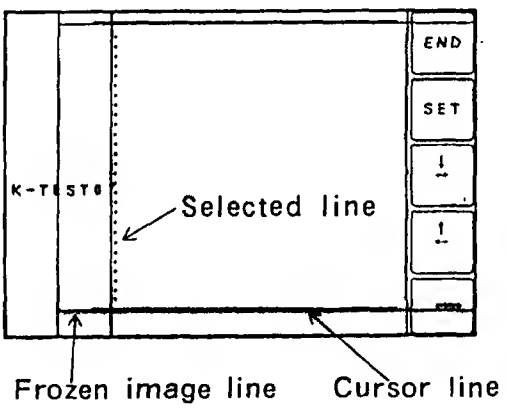
Realign to the model eye exactly and readjust the VR5 and VR6.

If the problem persists, adjust by step (26) then, readjust step (23) again.

(24) TEST K7 Adjusting the cursor position

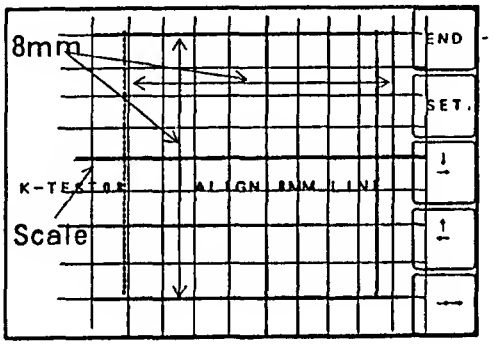
• Select TEST K7. A frozen screen will be displayed.

• Check : Make sure that the frozen image line(thin line) and the cursor line (thick line: character) overlap.



- Adjustment : Press the 「→→」 key to turn the cursor line to be adjusted to a broken line.
  Use the 「↓→」 or 「↑←」 key to move the broken line on the frozen image line.
  The numbers of presses the 「↓→」 or 「↑←」 key become the cursor position calibration values, and store this calibration value to EEPROM.
- Store to EEPROM : Set the DIP switch No. 5 to the ON position to enable storing. Press the 「SET」 key, and the calibration value will be stored into the EEPROM with two beeps.
- After store to EEPROM : Be sure to return the DIP switch No. 5 to the OFF position to the EEPROM store protection.

(25) TEST K8 Adjusting the cursor length
- Set the Model eye for Auto Keratometer(J38074) on the Forehead rest bar(A11)
- Select TEST K8.
- Model eye selection : Move and align the main unit with the Scale.
- Alignment : Move the main unit vertically and horizontally to overlap the cursor lines on the monitor screen and the Scale lines on the Model eye for Auto Keratometry(J38074).
  Move the main unit back and forth to bring the scale into focus.
- Check : The distance of the cursor lines must be 8 scale lines (8 mm).



- Adjustment : Press the 「→→」 key to turn the cursor line to be adjusted to a broken line.
  Use the 「↓→」 or 「↑←」 key to overlap the broken line to the scale which the distance of the cursor lines must be 8 scale lines.
  The numbers of presses of the 「↓→」 or 「↑←」 key become the cursor position calibration values, and store this calibration value to EEPROM.
- Store to EEPROM : Set the DIP switch No. 5 to the ON position to enable storing. Press the 「SET」 key, and the calibration value will be stored into the EEPROM with two beeps.
- After store to EEPROM : Be sure to return the DIP switch No. 5 to the OFF position for the EEPROM store protection.

(26) M mode Adjusting the video and still picture levels

- Set the flat part of auxiliary contrast and brightness control knob for the TV monitor(#1522) up (Inside the printer cover).
- Set the Accessory model eye on the Forehead rest bar(A11).
- Turn on the normal measurement mode and press the "M" key to enter the M mode.
- Alignment : Move the main unit vertically and horizontally to align the light spot of the M.LED and the center of the alignment mark on the monitor screen.
  Move the main unit back and forth to bring the metal circumference of the model eye into focus.
  At this point, fix the main unit with clamp(#6392 & #310).
- Press the Measurement button(#1528).
  The video picture will be frozen and a still picture appears.
  The video picture remains on the left side portion of the screen.
- Adjustment : While observing the screen, adjust the contrast and brightness using the VR9 and VR10 on the Kerato board(#1821).
  VR9 (DAGAIN)——→ Contrast
  VR10 (DABIAS) ——→ Brightness
  Also adjust the VR2 (ILLM) on the Refracto board(#1801) to set the intensity of Anterior illuminator(#1809).
  Adjust the VR7 on the Kerato board(#1821) so that the boarder line between the video and still pictures is inconspicuous.
  VR7 (DABIAS)——→ Border line
- Press the Measurement button(#1528) again to check whether the brightness is appropriate in the M mode.

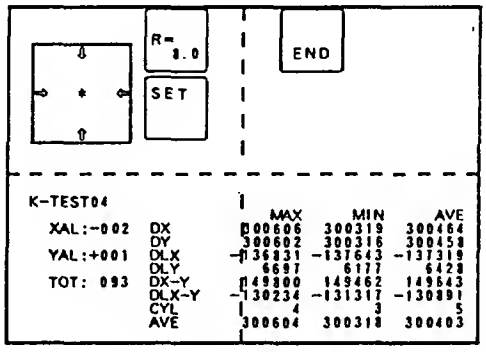
(27) TEST K3 Rechecking the K.LED intensity

- Set the Model eye for Auto Keratometer(J38074) on the Forehead rest bar(A11)
- Select TEST K1.
- Model eye selection : Press the Measurement button(#1528) to enter the Kerato mode.
  Move and align the main unit with the R11 model eye.
- Alignment : Move the main unit vertically and horizontally to overlap the four surrounding K.LED light spots and the broken cross line.
  Move the main unit back and forth to bring the four K.LED light spots into focus(Make the light spots round .)
  At this point, fix the main unit with the clamp(#6392 & #310).
  While taking care not to move the main unit, press the 「END」 key to exit the TEST K1 mode.
- Select TEST K3. The "MAX" and "MIN" measured values will be displayed.
- Check : Make sure that the intensity values of "K1" to "K4" are as follws :
  "MAX"——→"FF"
  "MIN"——→"1•" or "2•"
- Adjustment : Adjust the VR5 (ADGAIN) on the Kerato board(#1821) to set the "MAX" value to "FF".
  Adjust the VR6 (ADBIAS) on the Kerato board(#1821) to set the "MIN" value to "1•" or "2•".
  Adjust the VR5 and VR6 alternately.
- Intensity graph check : Press the 「SHAP」 key.
  The intensity graph will be displayed.
  Make sure that the waveforms of the four plots are of the same shape, size, and interval.
  The tops of each waveform must be flat.
- If the waveform of a plot is found poor : Realign to the model eye exactly and readjust the VR5 and VR6.

••: When readjust the VR5 and VR6, perform step (26) again.
Since step (23) and step (26) interfere with each other, be sure to take these steps alternately until both requirements are satisfied.

(28) TEST K4 Making of the Kerato model eye count table

- Set the Model eye for Auto Keratometer(J38074) on the Forehead rest bar(A11)
- Select TEST K4.
- Model eye selection : Move and align the main unit with the model eye that is displayed in the "R=•••" field.
- Alignment : Move the main unit vertically and horizontally to overlap the four surrounding K.LED light spots and the broken cross lines exactly. Move the main unit back and forth to bring the four K.LED light spots into focus.



- Measurement : Press the Measurement button(#1528) to start measurement. The measured data will be displayed. Make several measurements and take their average "DX,DY" values as the count data.
- Store to EEPROM : Set the DIP switch No. 5 to the ON position to enable storing. Press the 「SET」 key, and the count data will be stored into the EEPROM.
- Start measurements at the R3.0 model eye on the Model eye for Auto Keratometor(J38074).

After the measurement of the R3.0 model eye and the storage of its count data are completed, press the 「R=3.0」 key to proceed to the "R=4.0" field and start measurement of the R4.0 model eye.
Make measurements for R3.0 to R12.0 model eyes on the Model eye for Auto Keratometor(J38074) and store their count data in the EEPROM.

- After storing the count data for all model eyes, be sure to reset the DIP switch No. 5 to the OFF position for the store protection.
- Reference model eye count values (Used to check the R value of the model eye under measured.)

R= 3.0 ⟶ 109•••	R= 8.0 ⟶ 292•••
R= 4.0 ⟶ 146•••	R= 9.0 ⟶ 329•••
R= 5.0 ⟶ 184•••	R=10.0 ⟶ 366•••
R= 6.0 ⟶ 219•••	R=11.0 ⟶ 402•••
R= 7.0 ⟶ 256•••	R=12.0 ⟶ 439•••

(29) Measuring the Kerato model eye

- Press the 「END」 key to exit the Kerato test program, and the Refracto test selection menu screen will appear. Press the 「EXIT」 key on the Refracto test selection menu screen to return to the normal measurement mode screen.
- Press the 「K→R」 key to set the 「KER」 Kerato measurement mode in the normal measurement mode screen.
- Alignment : Move the main unit vertically and horizontally to align the light spot of the M.LED is positioned at the center of the alignment mark on the monitor screen. Move the main unit back and forth to bring the light spot of the M.LED into focus.
- Measurment : Press the Measurement button(#1528). The measured values will be displayed in the "R1,R2" field. Make several measurements.
- Check : Start measurements at the R4.0 model eye.
  Make sure that the measured data of all model eyes with R4.0 to R11.0 on the Model eye for Auto Keratometer(J38074) fall within the tolerance.
- Tolerance :

Kerato model eye	Tolerance
R 4.0	4.01 ±0.02 mm
R 5.0	5.03 ±0.02 mm
R 6.0	5.99 ±0.02 mm
R 7.0	7.00 ±0.02 mm
R 8.0	8.00 ±0.02 mm
R 9.0	9.00 ±0.02 mm
R10.0	10.01 ±0.02 mm
R11.0	11.00 ±0.02 mm